The whole subject was in that chaotic state which naturally precedes the advent of the Kepler who is to marshal, under a few general statements, each intrinsically simple, the mass of apparently irreconcilable phenomena.

Andrews' classical researches completely effected this simplification. Guided by the results of Regnault, he selected carbonic acid as the substance whose behaviour was made the subject of exhaustive study through wide ranges of temperature and of pressure. He devised an extremely ingenious form of apparatus for the purpose, had the coarser metallic parts constructed under his own eye by a remarkably skilful mechanic; and himself made and calibrated the glass portions, purified with great care and skill the gas to be operated on, and finally fitted up the whole with unwearying patience.

The simpler and more prominent results of this splendid research may be briefly summed up as follows:—

(*a*) When carbonic acid is maintained at any temperature whatever *above* 30°·9 C., it cannot even in part be condensed into liquid by any pressure however great.

(*b*) If the temperature be *below* 30°·9 C., the gradual increase of pressure ultimately leads to liquefaction; but the pressure of the vapour in presence of the liquid is less as the temperature is lower.

(*c*) A cycle of operations, in Carnot's sense, can be performed on liquid carbonic acid in such a way that, during the first stage of the expansion we have optical proof of the existence of liquid and gas side by side in the same vessel; while on compressing again at a higher temperature, and finally cooling down to the original temperature and volume, the whole contents are once more liquid; though at no stage of the latter part of the operation is there any appearance of the joint presence of two different states of matter. It is this fact which suggested the title of the paper.

(*d*) The key to the explanation of observed deviations from Boyle's Law was furnished by his study of the isothermals of carbonic acid at temperatures not much above 30°·9 C. For Andrews's measurements show that the product of pressure and volume (which, by Boyle's Law, should be constant) diminishes with volume to a minimum, and thereafter rises rapidly as the volume is farther diminished.

Many other valuable results, such as the great compressibility of liquid carbonic acid, especially at temperatures near to 30° C.; the alteration of surface-tension of the liquid, and of its angle of contact with glass, as the temperature is raised, &c., appear as mere side-issues of this investigation.

The discovery of this Critical Temperature, or Critical Point, soon led to the liquefaction (and in certain cases even to the solidification) of the gases which had been called "non-condensable." Andrews' work had supplied all the necessary hints for the adaptation of his apparatus to such a purpose. In fact the main requisites were (1) to work on a larger scale, (2) to employ very low temperatures, and especially (3) to provide a means of ensuring *sudden* relaxation of pressure. The work of Pictet, Cailletet, v. Wroblewski, Amagat, &c., on this subject, followed as a natural and immediate consequence of that of Andrews.

The writers have, like many others, seen and admired the confident manipulation, by Andrews, of wide sealed tubes, half full of liquid carbonic acid; how he, knowing the soundness of his own glass-blowing, boldly heated such tubes in the flame of a Bunsen lamp, till the liquid entirely disappeared, and pointed out with eager enjoyment the extraordinary phenomena presented as the contents cooled nearly to the critical temperature. The whole tube seemed, for a short time, to be filled with a substance presenting, to an exaggerated degree, the appearance of a mixture of water and alcohol before diffusion has sensibly operated.

We have spoken of Andrews's remarkable skill in manipulation, and of his unwearied patience. But even these were eclipsed by the perfect calmness with which, though on the very verge of an important discovery, he attended to every point of minute and laborious detail; so that his first successful experiment was as exactly carried out and recorded as was its future repetition. This was all the more remarkable in that he was usually, especially in public, a man of a highly nervous and excitable temperament.

An excellent French and German scholar, he kept himself always well acquainted with the most recent progress of science, whether chemical or physical. He constructed his own dividing-engine for the calibration of the exquisite thermometers which he made for his researches on heat; and his air-pump (in which he took special delight) was furnished with numerous valuable improvements all devised by him for particular applications. His laboratory books were models of ample, but not superfluous, detail.

He was, personally, a man of simple unpretending manner; conscientious almost to an extreme, but thoroughly trustworthy and warm-hearted; an excellent example of the true Christian philosopher.

NOTES

WE regret to announce the death of Mr. Alfred Tribe, the well-known chemist, on November 26, at the age of forty-six years. We defer to next number a notice of Mr. Tribe's career.

A MEETING of the subscribers to the testimonial to Dr. H. Woodward, F.R.S., for twenty-one years editor of the *Geological Magazine*, was held on the 15th inst., at the rooms of the Geological Society, Burlington House, when Prof. T. G. Bonney (Pres. Geol. Soc.) presented to that gentleman, on behalf of the subscribers, a silver tea and coffee service and a cheque for 253*l.* On making the presentation, Prof. Bonney addressed Dr. Woodward, referring to the invaluable services he had rendered to science during the twenty-one years he has had charge of the *Geological Magazine*. In replying, Dr. Woodward referred briefly to the career of the *Magazine* and its predecessors, to the many distinguished men that had been connected with them, and to the period of remarkable scientific interest thus covered. Over 200 names are on the list of subscribers to the testimonial.

THE 10th instant was a red-letter day at the French Institute. M. Bertrand was introduced as member of the Académie Française, and read an address which, according to custom, was devoted entirely to thanking his brother Academicians and to eulogising his immediate predecessor, M. Dumas. The address was acknowledged by another oration from M. Pasteur, who after having summarised the life of M. Bertrand, gave a long and interesting account of the career of M. Dumas. Great enthusiasm prevailed throughout the proceedings, and the hall was crowded.

THE number of patients in the special clinic of M. Pasteur is increasing daily, several arriving from foreign countries. No less than forty were inoculated on December 14 before the Minister of Agriculture, who acknowledged the services rendered by Pasteur to humanity. Among the patients is an officer of the Czar's body-guard, just arrived from St. Petersburg.

A BIOGRAPHY of the late Sir William Siemens is being prepared, at the desire of the executors, by Dr. William Pole, F.R.S., Hon. Secretary of the Institution of Civil Engineers, and author of the "Life of Sir William Fairbairn, Bart." Dr. Pole will be grateful for the loan of any of Sir William's letters, or for any information of importance. Address, Athenæum Club, S.W.

ON Saturday, last week, the rainfall at the Ben Nevis Observatory amounted to 4·991 inches, and on the Sunday following to 3·604 inches, there having thus fallen on these two days fully eight inches and a half. During this time the wind was westerly and north-westerly, force 2 of Beaufort's scale, with occasional squalls. On the Monday the wind was still westerly, and though no rain fell from 2 a.m. to 10 a.m., the rainfall for the twenty-four hours was 1·225 inch.

THE death is announced of Xavier Ullesberger, the well-known palæontologist, at Ueberlingen, on the Lake of Constance, at the age of seventy-nine. His special distinction is the discovery of the lacustrine villages in the Lake of Constance, at Nussdorf, Maurach, Uhldingen, and Sipplingen. The extensive collection of Celtic and prehistoric objects which he got together in the course of his researches is preserved at Stuttgart.

THE death of Mr. Edwin Ormond Brown, Assistant-Chemist to the War Department, occurred on Saturday last. Mr. Brown had been engaged in the chemical establishment at the Royal Arsenal, Woolwich, for about thirty years, and has been instrumental in the improvement of gun-cotton and other explosives, besides rendering useful services in other matters.

THE Earl of Iddesleigh gave a very sensible address the other evening to the students of the Exeter Science Classes, of which he is the patron. He spoke of the rapidly growing feeling in favour of scientific education, and of the results it had already accomplished for the individual and the nation. After referring to misconceptions as to what technical education really meant, the Earl said:—"There is no doubt that by technical education you may mean one of two things. You may either mean an advance in the teaching of the scientific principles on which industrial processes depend, or you may mean the teaching of those processes practically and illustratively in the school rather than in the workshop. There is a very great difference between these two things. It may be desirable at times to give a certain amount of instruction in schools of a practical character, but that must not be pushed very far. It must be borne in mind that technical teaching, to be of real service, must be obtained in the course of work itself in the workshop. But with regard to the principles on which the processes of manufacture rest, those principles can only be taught in the schools, and it is to the development of those principles that we ought to pay most attention. That is the advantage which in schools of this kind you get. The study of pure and unapplied science is interesting to every one, but it does not at once appear that it has a direct bearing on the pursuits and callings of those who indulge in it. I daresay you may have heard the old question put, 'What is the use of any purely scientific discovery?' For answer another question was asked, 'What is the use of a baby?' The question is, What will it turn out to be? How will it be brought up, and how will it be brought into play?" The Earl of Iddesleigh then quoted the following passage from Prof. Huxley:—"'If you could, in the first place, keep your elementary scholars long enough to put them through a fair training in the principles of which the application lies in the special direction of metallurgy, and, secondly, if you could secure that they should acquire a special proficiency in such subjects, I think that would be a most admirable thing to do; but I thing the way it would work out under the present conditions would be this, that you would have special classes set up to grind young fellows without any knowledge of principles in that which would be no better than a rule of thumb. I do not believe that that would be of the smallest good. I believe, on the contrary, that it would do endless harm, because there would be a sort of pre-supposition that these young men really had the knowledge which would enable them to advance and improve their methods, whereas in reality the knowledge they possessed would be nothing more than a little of the ordinary *technique* of their business varnished over with scientific phraseology. What you want," the Earl said, "is what Prof. Huxley says you want, as far as you can get it—the education to turn upon the principles on which the true science is based, as distinguished from the application of the science. Having got that, you will find that there will be abundance of opportunity to apply to the arts which you are about to prosecute the principles you have learnt. These principles I believe to be the main secret of what is sometimes called scientific, and sometimes called technical, education."

THE Royal Geographical Society will hold a special meeting on Monday, December 21, to welcome Major Greely, the distinguished Arctic explorer, and hear him tell the story of his work and adventures in the Polar Seas.

THE Natural History Museum at Vienna has just been presented with 708 skulls collected through a series of years by Dr. Weissbach, who was for a long time director of the Austro-Hungarian hospital at Constantinople, and was a very distinguished anthropological investigator. Of the collection 195 are pure Turkish skulls, 131 Greek, 96 Servian or Croat, 48 Hungarian, 43 Armenian, 29 old Byzantine. There are also skulls of Maronites, Albanians, Koords, Asiatic Jews, &c.

AS No. 1 of the Special Papers of the Alabama Weather Service we have an interesting record of the weather from 1701 to 1885, by Capt. W. H. Gardner, of Mobile.

SCIENCE has, on the whole, no reason to quarrel with the results of the General Election. Sir Lyon Playfair is returned by a large majority for one of the divisions of Leeds; and Sir John Lubbock again takes his seat unopposed for London University. A new and very important addition to the ranks of scientific men in Parliament is Sir Henry Roscoe, who was elected after a sharp contest for South Manchester. His election is striking in one way, for he is the only Liberal returned in the six divisions of Manchester. Sir Edward Reed retains his former seat for Cardiff, but Prof. Rücker, of the Yorkshire College, failed to win a place. The medical profession is even more strongly represented than it was before. Dr. Foster, Professor of Medicine in the Queen's College, Birmingham, was elected for Chester, and Mr. Erichsen, the eminent surgeon, is a candidate for St. Andrews and Aberdeen Universities. Even amongst the followers of Mr. Parnell, there are members of the medical profession. Mr. Ernest Hart, however, has been rejected by Mile End.

WE have received the last part (vol. i. part 5) of the *Proceedings* of the Perthshire Society of Natural Science for the session 1884–85. It contains a series of museum notes, by Dr. Buchanan White, the indefatigable President for the current year, which are intended to form a guide to the museum subsequently; two papers on the comparative anatomy of the teeth, by Mr. James Stewart; the diatoms of the Tay, by Dr. Trotter; shells—their structure, growth, and use, by Mr. Coates; the climate of the British Islands, with special reference to Perthshire, by the Rev. A. Campbell; the native timber trees of Perth, by Mr. Lindsay; and some minor contributions. The presidential address is devoted to the exceedingly practical subject of explaining why the growth of the museum renders considerable increase of space necessary, and the cost of the consequent building operations. An appeal is also made for further specimens for the Perthshire collection of natural history—an appeal which we trust may meet with adequate response, for apart from the general public benefit of local museums as centres of education throughout the country, they are of universal scientific importance when they are made the depositories of specimens of the natural history, past and present, of their respective neighbourhoods. But to be of the fullest value in this respect, they must be made as complete as possible.

MESSRS. MACMILLAN AND CO. will publish next week the Essex Field Club Report on the East Anglian Earthquake of April 22, 1884. This Report has been drawn up by Prof. Raphael Meldola and Mr. William White, and will contain maps and several illustrations.

THE jubilee volume of the Statistical Society will shortly be published by Mr. Stanford, of Charing Cross. It will contain the proceedings of the jubilee meeting of the Society held in June last, and will comprise valuable papers by the President, Sir Rawson W. Rawson, Dr. F. J. Mouat, M. Levasseur, and Prof. Neumann-Spallart, at whose initiation the International Statistical Institute was then founded.

FRESH earthquake shocks have been felt in the district round M'sila during the last week and principally on Saturday, December 12. They have also been felt at Bordj-ban-areridj and Setif. The new road from Setif to Bordj has been cut by rocks falling from the surrounding mountains. A bridge has been destroyed and a railway station demolished. It is impossible up to this time to state whether the commotion originated in the Atlas or in the Hodna region, where M'sila is placed, not far from a large Sebbha, which, although almost dry in summer-time, contains a large quantity of water in rainy periods. Official documents will be sent to the Paris Academy of Sciences as soon as collected, but it is feared they will lack precision; no seismograph, so far as our knowledge goes, having been established in Algiers.

ADVICES from Smyrna in Asia Minor to November 25 state that a series of earthquakes, commencing on the 13th, had up to that time been felt at Denizlu in the interior, about 200 miles to the east. These disturbances were slight, but accompanied with subterranean noises.

WE are glad to see that the extremely valuable meteorological observations which were made at Sagastyr, the Arctic Station in the Delta of the Lena, during the years 1882 to 1884, are already being published. The last issue of the *Izvestia* of the Russian Geographical Society contains a preliminary report, by M. Yurgens, and several meteorological tables, namely, the observations in full, from September 1, 1882, to September 1, 1883, of the barometer, temperature of the air, of the surface of the soil and of the snow, and of the soil at a depth of 1 metre, the relative humidity, force of wind, and nebulosity; and the monthly averages of the above for each hour of the day. The magnetical observations for the same period are being calculated, as also those for 1883 and 1884. The whole, together with observations of the temperature of the soil at depths of 80 and 160 centimetres, temperature and density of water, tides, and auroræ will be published in a separate form. A map of the Delta of the Lena, based on new surveys, and a plan of the station accompany the report of M. Yurgens, which is very interesting, as it contains many details as to the life at the station, and varied information as to the Delta, and the excursions made during both summers. It is worthy of notice that the meteorologists of the station, although lost amidst tundras in the 73rd degree of latitude, were not so secluded from the world as might have been supposed. They received letters regularly from Yakutsk, together with newspapers and reviews, which reached them four months after their publication at St. Petersburg—a delay which is not so great if it be taken into account that letters take nearly one month to reach Irkutsk, the capital of Eastern Siberia. As to the frozen mammoth whose remains were explored by Dr. Bunge, only pieces of bones and traces of the contents of the stomach were found and brought to St. Petersburg.

THE additions to the Zoological Society's Gardens during the past week include a Rhesus Monkey (*Macacus rhesus* ♀), two Grey-breasted Parrakeets (*Bolborhynchus monachus*) from Monte Video, presented by H.R.H. the Prince of Wales, K.G.; two West Indian Agoutis (*Dasyprocta cristata*) from West Indies, presented by T.R.H. Prince Albert Victor and Prince George Frederick of Wales; a Macaque Monkey (*Macacus cynomolgus* ♂) from India, presented by Mr. Jan Smidt; a Pig-tailed Monkey (*Macacus nemestrinus*) from Java, presented by Miss Ethel Rodger; two Tigers (*Felis tigris*) from Hyderabad, presented by the Nawab Salar Jungh Bahadur; a Cheetah (*Cynælurus jubatus*) from Afghanistan, presented by the Nawab Mahomed Hassan Ali Khan; a Tiger (*Felis tigris*).

OUR ASTRONOMICAL COLUMN

BRIGHT LINES IN STELLAR SPECTRA.—Mr. O. T. Sherman has continued his researches on the spectra of γ Cassiopeiæ and and β Lyræ, and announces in the *American Journal of Science* for December the discovery of no fewer than fifteen in the spectrum of the former star, and seventeen in that of the latter. The lines seen in γ Cassiopeiæ are as follows:—Hα, λ 6356, 6160, D_3, λ 5840, 5557·5, 5422, 5309·8, 5167·5, 4990, Hβ, λ 4623, Hγ, λ 4180, and Hδ, bright lines; and λ 6280, 5760. 5020, 4920, 4673·5, and 3993, dark lines. The bright lines agree closely in position with the principal lines observed by Prof. Young in the spectrum of the chromosphere.

Mr. Sherman has also examined a large number of other stars, and "*in each case* many or few bright lines have been seen, lines, so far as I know, formerly unsuspected." It is clear, if Mr. Sherman's observations can be satisfactorily confirmed, that we have here a most important discovery; but looking to the fact that these stars have probably been frequently observed by experienced spectroscopists without any bright lines being detected in them, whilst a false appearance of bright lines is readily produced in stellar spectra under certain circumstances, it would appear hazardous to accept Mr. Sherman's result without further evidence.

PHOTOMETRY OF THE PLEIADES.—A valuable memoir (*Mémoires de l'Academie Impériale des Sciences de St. Pétersbourg*, vii. série, tome xxxii. No. 6) by Herr Ed. Lindemann of Pulkowa, "On the Magnitudes of Bessel's Stars in the Pleiades," has recently reached us. A special point of interest lies in the fact that Profs. Pickering and Pritchard have likewise determined the brightness of many of these stars with their respective photometers, each assuming the magnitude of Merope, to which the other stars of the group are referred, as 4·22. Herr Lindemann has also adopted the same magnitude for Merope, which he has used as his standard star. He also employed, as reference stars, Celæno and Anon 32, the magnitudes of which he had determined to be 5·27 and 6·51 respectively. The stars, fifty-two in number, were each observed on two separate nights, only one star of the fifty-three observed by Bessel proving too faint for Herr Lindemann's telescope of five inches aperture. Comparing his own results with those of Profs. Pickering and Pritchard, Herr Lindemann finds, on the whole, a very gratifying agreement; twenty-five stars observed by Prof. Pickering showing a mean excess over the Pulkowa observations of 0·04 of a magnitude, and thirty-three stars observed by Prof. Pritchard giving a mean excess of 0·05. Prof. Pritchard's later observations give a yet smaller difference, viz. 0·01 of a magnitude. When it is remembered that the three photometers employed—Herr Lindemann using a Zöllner photometer—differed entirely in principle, construction, and method of employment, this close agreement would seem to indicate that each may be relied upon with very considerable confidence, when the differences of stellar magnitude determined by their means are not very great. The stars Nos. 1, 4, 21, 31, and 33 would appear to be variable, and possibly two others likewise. Pogson's scale has been employed for the conversion of the logarithm of the light of the star into magnitude.

FABRY'S COMET.—The following elements and ephemeris have been computed for this comet by Dr. H. Oppenheim:—

Perihelion Passage, 1886 March 9·7944 Berlin M.T.

$$\left.\begin{array}{rcrrr} & & {}^{\circ} & {}' & {}'' \\ \omega & = & 132 & 36 & 19 \\ \Omega & = & 32 & 17 & 32 \\ i & = & 47 & 18 & 0 \end{array}\right\}\text{Mean Eq. } 1885\cdot0$$

$$\log. q = 9\cdot69654$$